GOVERNMENT OF PUERTO RICO
PUERTO RICO PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: INTERRUPCIÓN DE SERVICIO ELÉCTRICO DE 12 DE JULIO DE 2022	**CASE NO. NEPR-IN-2022-0003** **SUBJECT:** **Motion to Submit Redacted Versions of Preliminary Report, August Monthly Progress Report, and Final Report of July 12th Incident**

MOTION TO SUBMIT REDACTED VERSIONS OF PRELIMINARY REPORT, AUGUST MONTHLY REPORT, AND FINAL REPORT OF JULY 12TH INCIDENT

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COME now **LUMA Energy, LLC** ("ManagementCo"), and **LUMA Energy ServCo, LLC** ("ServCo"), (jointly referred to as the "Operator" or "LUMA"), and respectfully state and request the following:

1. On July 12th 2022, a failure in the electric system led to a fire at the 115 kV/4 kV Jayuya Substation, which resulted in a power outage in the municipality of Jayuya (hereinafter, the "July 12th Incident").

2. On July 13th 2022, this Honorable Puerto Rico Energy Bureau ("Energy Bureau") issued a Resolution and Order whereby it initiated a confidential investigation of the July 12th Incident ("July 13th Order").

3. The July 13th Order instructed LUMA: (i) to submit, on or before July 19th, 2022, at 3:00 p.m., a preliminary report on the causes of the July 12th Incident and the corrective actions taken by LUMA (the "Preliminary Report"); (ii) to submit on or before October 15th 2022, at 3:00

p.m., a final and more detailed report on the July 12th Incident (the "Final Report"); and (iii) to submit monthly progress reports (the "Monthly Progress Reports") until LUMA filed its Final Report on the July 12th Incident.

4. After requesting an extension of time, on July 17, 2022, LUMA filed the Preliminary Report of the July 12th Incident. The Preliminary Report includes confidential information which was filed under seal of confidentiality as it constitutes Critical Energy Infrastructure Information ("CEII") that garners protection from public disclosures pursuant to federal statutes and regulations see, e.g., 6 U.S.C. §§ 671-674; 18 C.F.R. §388.113 (2020), and the Bureau's Policy on Management of Confidential Information. See Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009 ("Policy on Management of Confidential Information"), issued on August 31, 2016, as amended by the Resolution dated September 16, 2016. 17.

5. On August 31, 2022, LUMA filed a Monthly Progress Report of the July 12th Incident (the "August Monthly Progress Report"), which provides an update on the restoration efforts performed to stabilize the system and return the Jayuya station to normal operations.[1] LUMA submitted the August Monthly Progress Report under seal of confidentiality and respectfully submitted that the August Monthly Progress Report should be designated by the Energy Bureau as confidential material that should be protected from disclosure even after the

[1] LUMA intended to file another Monthly Progress Report on or before September 30, 2022 (the "September Monthly Progress Report"). However, the passage through Puerto Rico of Hurricane Fiona on September 18, 2022, required the deployment of LUMA's workforce to prepare for and address an island-wide emergency, resulting in an unforeseen delay in gathering important information. As a result, on September 30, 2022, LUMA filed an informative motion to inform the Energy Bureau that it was not going to be able to file a September Monthly Progress Report. Nevertheless, LUMA informed the Energy Bureau that it intended to file the Final Report of the July 12th Incident on or before October 15, 2022, as required by the July 13th Order.

investigation of the July 12th Incident concludes because it is protected from disclosure as CEII, *see, e.g.*, 6 U.S.C. §§ 671-674; 18 C.F.R. §388.113 (2020), and pursuant to the Bureau's Policy on Management of Confidential Information.

6. In compliance with the July 13th Order, on October 15, 2022, LUMA filed the Final Report of the July 12th Incident. LUMA submitted the Final Report under seal of confidentiality and respectfully submitted that the Final Report should be designated by the Energy Bureau as confidential material that should be protected from disclosure even after the investigation of the July 12th Incident concludes because it is protected from disclosure as CEII, *see, e.g.*, 6 U.S.C. §§ 671-674; 18 C.F.R. §388.113 (2020), and pursuant to the Bureau's Policy on Management of Confidential Information

7. On April 17, 2023, the Energy Bureau issued a Resolution and Order (the "April 17th Order"), whereby it adopted LUMA's Final Report and recommendations on the July 12th Incident and concluded that LUMA complied with the July 13th Order. Nevertheless, the April 17th Order instructed LUMA to submit, on or before April 27, 2023, public redacted versions of the Preliminary Report, the August Monthly Progress Report, and the Final Report of the July 12th Incident.

8. In compliance with the April 17th Order, LUMA hereby submits public redacted versions of: (i) the Preliminary Report of the July 12th Incident (attached hereto as Exhibit A); (ii) the August Monthly Progress Report of the July 12th Incident (attached hereto as Exhibit B); and (iii) the Final Report of the July 12th Incident (attached hereto as Exhibit C).

9. Considering the above, LUMA respectfully requests the Energy Bureau to close the instant proceeding.

WHEREFORE, LUMA respectfully requests that the Energy Bureau **take notice** of the aforementioned, **accept** the reports that are being filed as Exhibit A, Exhibit B, and Exhibit C to this Motion, **deem** LUMA complied with the April 17th Order, and **close** the instant proceeding**.**

RESPECTFULLY SUBMITTED.

We hereby certify that we filed this Motion using the electronic filing system of this Energy Bureau and that we will send an electronic copy of this Motion to the attorney for the Puerto Rico Electric Power Authority, Joannely Marrero, jmarrero@diazvaz.law.

In San Juan, Puerto Rico, this 27th day of April 2023.

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Exhibit A

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Jayuya 115/4.16 kV Substations 8301 and 8302 Outage July 12, 2022

Event and Restoration Report

July 21, 2022

Part of this document is protected from disclosure as Critical Energy Infrastructure Information ("CEII"), in accordance with 6 U.S.C. §§671-674; ;18 C.F.R. §388.113 (2020), and pursuant to the Puerto Rico Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009, issued on August 31, 2016, as amended by the Resolution dated September 16, 2016.

Summary

In compliance with Puerto Rico Energy Bureau's Resolution and Order issued July 13, 2022 in case number NEPR-IN-2022-0003, LUMA is providing data collected and initial findings herein for the July 12, 2022 outage event at Jayuya Substation.

Since beginning operations on June 1, 2021, LUMA has been focused on repairing, restoring, and fundamentally transforming and modernizing Puerto Rico's energy system that has long suffered from years – if not decades – of neglect under the prior operator. As has been well documented, nearly every aspect of the energy grid across Puerto Rico, including substations and other critical aspects of the T&D system, were weakened by past operational and maintenance failures, such as lack of maintenance and modernization.

With respect to the July 12th, 2022 Jayuya event, LUMA is committed to investigating the factors that may have led and contributed to this specific substation event, including 1) identifying and understanding the root cause(s) of this event, 2) the role and impact played by the fragile nature of the grid, and 3) the series of actions and improvement(s) that must be taken by LUMA, and other actors, to help mitigate against similar incidents occurring again.

As part of our commitment to transparency, LUMA will provide additional updates on the investigation, and will work with Puerto Rico Electric Power Authority (PREPA) and other parties in order to address their questions and to determine subsequent corrective actions.

Event Update

This report is based on the outage event data, restoration timeline, and repair update of the disturbance event that caused a power outage on July 12th, 2022.

At 5:50 a.m., a fault occurred in the Jayuya substations, (the Jayuya 1 substation and Jayuya 2 substation), resulting in the substations being de-energized, affecting 6,208 customers. Restoration began at 06:50 with the arrival of the first responders. Restoration was complex and laborious. It consisted of grounding, clean-up, isolation, electrical testing and system reconfiguration. Of the five feeders supplied by the substations, three were restored at approximately 5:00 p.m. and the remaining two were restored at approximately 5:30 p.m. All customers were fully restored approximately 12 hours after the initial fault.

The Jayuya substations are fed from two 115 kV lines (39000 and 36400) and have two transformers that step-down voltage to supply the five 4.16 kV distribution circuits (8301-01 (F1), 02 (F2) and 03 (F3) and 8302-04 (F4) and -05 (F5)). See Figure 1-1 Jayuya Substations.

An initial fault occurred on the downstream side of feeder circuit breaker F5 based on the significant thermal damage to the circuit breaker. The circuit breaker failed to clear the fault, which resulted in the melting of the high-side fuses of the transformers. A 115 kV fault developed after about 45 seconds, causing lines 39000 and 36400 to trip (via circuit breakers at remote terminals) and de-energize the substations. While an understanding of the steps leading to the event is clear, additional information and analysis will be necessary to determine the initial and exact cause of the outage.

The following report presents a detailed analysis of the restoration update, electrical repair and next steps.

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List of Acronyms

- Current Transformer (CT)
- Feeder Circuit Breaker (FCB)
- Generator Circuit Breaker (GCB)
- Motor-Operated Disconnect (MOD)
- Oil Circuit Breaker (OCB)
- Potential Transformer (PT)
- Remote Terminal Unit (RTU)
- Transmission Center (TC)

1. Overview of Event

1.1 Event Details

- Event name: 12JUL2022 Jayuya Outage Event
- Outage date: July 12th, 2022
- Outage time: 5:50 a.m.
- Number of customers impacted by event: 6,208
- Location: Jayuya 115/4.16 kV substations 8301 and 8302
- Description: An initial fault occurred on the downstream side of feeder circuit breaker F5, based on the significant thermal damage to the circuit breaker. The circuit breaker failed to clear the fault, which resulted in the melting of the high-side fuses of the transformers. A 115 kV fault developed after about 45 seconds, causing lines 39000 and 36400 to trip (via circuit breakers at remote terminals) and de-energize the substations. The outage affected 6,208 customers. All customers were fully restored approximately 12 hours after the initial fault.

1.2 Overview of Event

On July 12th, 2022 at 5:50 a.m., a fault occurred in the Jayuya substations that resulted in the substations being de-energized affecting 6,208 customers.

The Jayuya substations are fed from two 115 kV lines (39000 and 36400) and have two transformers that step-down voltage to supply the five 4 kV distribution circuits (8301-01 (F1), 02 (F2) and 03 (F3) and 8302-04 (F4), and -05 (F5). See figure below.

Figure 1-1 Jayuya Substations

An initial fault occurred on the downstream side of feeder circuit breaker F5, based on the significant thermal damage to the circuit breaker. The circuit breaker failed to clear the fault. This resulted in some of the high-side fuses of the transformers melting. The 4.16 kV fault persisted and, after about 45 seconds, evolved into a 115 kV fault. The 115 kV fault caused lines 39000 and 36400 to trip (via circuit breakers at remote terminals) and de-energize the substation.

2. LUMA's Response to the Outage

LUMA is committed to building an energy system the people of Puerto Rico can rely on. When outages do occur, LUMA strives to take swift action to restore power as quickly and safely as possible and provide the reliability and resiliency our customers expect and deserve.

2.1 Restoration Timeline

- **05:50 h** - At 5:50 a.m., a fault occurred in the Jayuya substations, resulting in the substations being de-energized, affecting 6,208 customers. There is no way to restore power in Jayuya on the distribution side upon the loss of the 115 kV source. The 5 feeders in Jayuya required the substation and the 115kv source to provide power to customers.
- **06**:**50h** – crew members began arriving on site to start isolation activities and form restoration plan. The plan consisted of:
    - Isolating damaged 4KV Breakers 4 and 5
    - Isolating MOD 36447 for further evaluation
    - Grounding substation for safety and,
    - Clean Busses 1 and 2
    - Test Transformers 8301 and 8302
    - Make Portable unit #11 on ready for hot standby in case needed (Bayamon TC)
    - Replace blown fuses on transformer 8301 and 8302
    - Test RTU (remote terminal unit) and verify station DC
    - Throughout the outage, System Operations supported the Operation team with line clearance, permits, switching.
- **1100 h** - damage assessment was completed by substation personnel. Isolation of damage equipment, testing of transformers and replacement of damaged disconnect switches commenced.
- **16:32 h** - Line 36400 was energized from Dos Bocas (circuit breaker #36450) down to Jayuya. Substation 8302 and bus 4.16 kV for substation 8301 were energized. Bus tie circuit breaker 4.16 kV was closed to be able to energize substation 8301 distribution bus through substation 8302. Substation 8301 was available but not energized.
- **16:43 h** - The circuits fed from the undamaged circuit breakers were restored to normal service after the station was re-energized: feeders F1, F2, and F3 remained in service while feeders F4 and F5 remained out of service pending replacement.
- **17:30 h** - The circuits fed from the damaged circuit breakers were restored vie ties to other feeders. Feeder F4 loads feed thru feeder F1. Feeder F5 loads feed thru F3. All customers are fully restored.

3. Damage Assessment and Affected Assets

3.1 List of Failed and Damaged Equipment

The below reflects the assessed failed and/or damaged equipment after the fault.

- Two 4.16 kV circuit breakers failed (feeders F4 and F5).
- One PT on the 4.16 kV bus failed.
- Six 4.16 kV fuse disconnect switches failed (metering and AMR circuits).
- Twelve 4.16 kV solid-blade disconnect switches failed (auxiliary switches for circuit breakers F4 and F5).
- 4.16 kV bus support and bus bar incurred damage at substation 8302.
- 115 kV bus support incurred damage at substation 8301.
- 115 kV insulator incurred damage at substation 8302.
- Jayuya's RTU failed.
- One 115 kV S&C Electric Company type SMD 2B – 65E standard speed fuse extinguished in 115/4.16 kV substation 8302.
- Two 115 kV S&C Electric Company type SMD 2B – 65E standard speed fuses extinguished in 115/4.16 kV substation 8301.

Table 3-1 Other Major Equipment Affected

Equipment Type	Equipment No/Name	Date out (mm/dd/yyyy)	Time out	Date in (mm/dd/yyyy)	Time in	Duration (hr:min)
115/4.16 kV	8301	07-12-2022	05:51:00			
115/4.16 kV	8302	07-12-2022	05:51:00	07-12-2022	16:32:00	10:41
4.16 kV FCB	F1	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F2	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F3	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F4	07-12-2022	05:50:00	07-12-2022	17:30:00	11:40
4.16 kV FCB	F5	07-12-2022	05:51:00	07-12-2022	17:30:00	11:40
115 kV GCB	36450	07-12-2022	05:51:00	07-12-2022	16:32:00	10:41
115 kV OCB	39080	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00
115 kV OCB	39062	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00
115 kV OCB	39042	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00

Figure 3-1 Photo of Damaged Circuit Breakers, Disconnect Switches, and Associated Hardware After Fault

Figure 3-2 Photo of Damaged Circuit Breakers, Disconnect Switches, and Associated Hardware After Fault

Figure 3-3 Photo of Substation Damage - Side View

4. Event Details

The event details are based on the information available at the time. As the investigation progresses and new information emerges, the Event and Restoration report will be amended if required.

4.1 System Status Prior to Event

The pre-disturbance/initiating conditions are presented in the figure below.

- Substations 8301 and 8302 were tied at the 4.16 kV since May 2022.
- 115 kV line 36400 from Dos Bocas was feeding both substations, via 115 kV circuit breaker #36450 and 115 kV MOD #36467.
- 115 kV MOD #36447 from Jayuya to line 39000 was open.
- Line 36400 to Ponce has been out of service since the 2017 hurricanes.
- A bypass with line 39000 was constructed to allow service to Jayuya via three terminal lines: 39000 from Toro Negro hydroelectric plant, Barranquitas, and Juana Díaz TC.

Figure 4-1 System Configuration Prior to the Event

Figure 4-2 115 kV System Single-line Diagram

4.2 Timeline of Events

The below summarizes the timeline of the events of the outage, from restoration, and to normal state.

Figure 4-3 Timeline of Events

Time	Event
05:50:43.095	A three-phase fault is observed at the distribution level on line 36400 by the digital fault recorder at Dos Bocas.
05:50:43.635	Short-circuit current magnitude decreased at line 36400 as the F4 feeder's trip is shown in SCADA.
05:50:46.979	Short-circuit current magnitude at 115 kV phases A and B decreased for a short period and resumed afterward.
05:50:51.000	SCADA shows RTU failure signals.
05:51:26.160	A 115 kV side fault at Jayuya is sensed by the digital fault recorders.
05:51:26.790	The 115 kV OCB #39080 at Toro Negro hydroelectric plant opens to isolate the fault from that terminal.
05:51:26.910	115kV GCB #36450 at Dos Bocas opens to isolate the fault from that terminal.
05:51:27.140	The 115 kV fault evolves to a phase-to-phase (A-C) fault.

05:51:27.250	The 115 kV OCB #39042 at Barranquitas TC trips.
05:51:27.461	115 kV OCB #39062 at Juana Díaz TC trips and clears the faults at Jayuya's substations from the system.
	System in normal state

4.3 Technical Details

4.3.1 Frequency Changes

Table 4-1 Frequency Changes Before the Event

Prior to Event (Hz)	Immediately After 38 kV Event (Hz Maximum and Minimum)
59.95	59.8

4.3.2 Voltage Changes

Table 4-2 Voltage Changes at Dos Bocas 115 kV

Before (P-P kV maximum/minimum)	During (kV minimum)	After (kV maximum/minimum)
67.95/67.83	36.48	68.15/67.97

5. Restoration Plan and Next Steps

5.1 Restorative Actions

LUMA has completed or is in the process of completing the following actions to restore the Jayuya substations from the impacts due to the July 12th, 2022 outage.

LUMA is currently investigating the material requirements for the repairs and restoration work and, provided that all materials are available, the tentative schedule will have the Jayuya substations restored to normal by the end of July 2022.

The following restorative actions have been completed or are underway:

- Performed Megger, CT ratio, and power factor tests to onsite replacement circuit breakers for FCBs F4 and F5. Timing and velocity tests are being scheduled. The damaged FCBs F4 and F5 will be removed as well as 12 damaged disconnect switches.
- Installing replacement FCBs F4 and F5 and then commissioning.
- Replacing damaged control and power wiring.
- Replacing RTU damaged input and output cards. Once completed, the RTU will be commissioned to the interface point.
- Repairing transformer 8301's tap changer.
- Energizing transformer 8302 when all repairs in the substations have been completed.

5.2 Next Steps

LUMA is committed providing a complete analysis of the Jayuya event, and will prepare an additional investigation report by October 15, 2022 that will present specific findings, as well as identify key actions and next steps . The next report related to the July 12 Jayuya substation outage event will:

- Perform distribution line patrols to determine initial cause of the outage.
- Evaluate the protection system's performance.
- Investigate possible communications issues that resulted from the failed remote terminal unit (RTU).
- Finalize repairs outlined in Section 5.1

Exhibit B

12 JUL 2022 – Jayuya Substation – Update Report

August 31, 2022

CONFIDENTIAL/PROPRIETARY: In the interests of protecting the electric infrastructure of Puerto Rico, portions of this document are protected from disclosure as Critical Energy Infrastructure Information ("CEII"), in accordance with 6 U.S.C. §§671-674; 18 C.F.R. §388.113 (2020), and pursuant to the Puerto Rico Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009, issued on August 31, 2016, as amended by the Resolution dated September 16, 2016.

DISCLAIMER: The information provided in this document in the following sections is based on the facts known to LUMA as of August 31, 2022. LUMA reserves its right to supplement or modify this document if additional facts become available as part of the investigation.

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1.0 Restoration Updates

The following section describes the restoration efforts that were preformed to stabilize the system, restore the customers, and return the station to normal operations.

1.1 July 12, 2022 – Recovery steps on the day of the Event

The sequence of events of the restoration activities shortly after the outage and after the site was secured are shown below.

16:32 h - Line 36400 energized from Dos Bocas (circuit breaker 36450) down to Jayuya. Substation 8302 and bus 4.16 kV for substation 8301 were energized. Bus tie 4.16 kV was closed to energize substation 8301 distribution bus via substation 8302.

16:43 h - The circuits fed from the undamaged circuit breakers were restored to normal service after the station was re-energized. Feeders 8301-01, -02, and -03 remained in service. Feeders 8302-04 and -05 remained out of service, pending replacement.

17:30 h - The circuits fed from the damaged circuit breakers were restored vie ties to other feeders. Feeder 8302-04 loads feed thru Feeder 8301-01. Feeder 8302-05 loads feed thru Feeder 8301-03.

1.2 Repairs and Replacements

Restoration efforts continued from the next day, with the field crews working 10 hours/day. The repairs were completed on July 22, 2022, as per the schedule established.

1.2.1 Breakers 4 and 5 Replacement

Replacement Breakers arrived on site on July 13, 2022, and the Insulation, CT ratio, and Power Factor Tests were completed.

LUMA Protection team initiated the relay setting calculations for the 2 breakers.

Twelve (12) Damaged Auxiliary switches for breakers 4 and 5 were removed, and crews were getting ready to remove both damaged breakers as well.

The crews initiated the replacement of damage control and power wiring. This job took 7 days to complete.

On the second day, the insulation, timing, and velocity tests for the replacement breakers were completed. The new auxiliary switches and all control cables arrived on site and ready to be installed.

On July 22, 2022, the installation of two new Mitsubishi feeder breakers was completed at positions 4 and 5 with two SEL-751A protection relays per breaker.

Settings programmed as per the following work orders:

Redacted

Redacted

Feeders 1, 2, 3, 4, 5 will be energized through transformer 8301. Meanwhile Transformer 8302 will be Out of Service for maintenance purposes. Once Transformer 8302 is ready to be In Service, feeders 4 & 5 will be transferred back to transformer 8302. Coordination was verified for both scenarios.

Please note that a recloser will be install downstream of feeder 5. New settings for feeder 5 will be issued once the recloser is installed.

1.2.2 RTU work

LUMA Telecom crew initiated replacement of several damaged input and output cards within the RTU.

On July 14, 2022, the RTU was partially in service with metering functions operational. The team assessed the spares required to complete repairs and enable the control functions.

On July 21, 2022, all repairs were completed, and the RTU was commissioned to the interface point.

The insulation of the Trip and Close wires going from the RTU to the MOD control cabinet were tested.

1.2.3 Transformer 8301 Tap Changer and Overall Maintenance

The field assessment to determine spare parts required was completed on the first day. On the second day, the tap changer was repaired, and the crews continued ratio testing this transformer.

Complete maintenance was performed, including insulation test, TTR, Excitation test, Bushing test, lighting arrest test, and demagnetization test, getting satisfactory results.

Power factor, breakdown, and acidity tests on the transformer oil were also completed.

1.2.4 Transformer 8302

The 14 MVA transformer was energized on July 12th, 2022, carrying all the load for the substation (6.5MVA). The fan was set on manual, and the winding and oil temperatures are holding at 42 degrees. The Tap Changer changed positions from -1 to +2. Voltage regulation is very good.

2.0 Next Steps

LUMA will continue to finalize the report, including any additional efforts related to restoration activities, causes, and lessons learned.

Exhibit C

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Jayuya 115 kV/4.16 kV Substations #8301 and #8302 Outage July 12, 2022

Final Report

October 14, 2022

Part of this document is protected from disclosure as Critical Energy Infrastructure Information ("CEII"), in accordance with 6 U.S.C. §§671-674; 18 C.F.R. §388.113 (2020), and pursuant to the Puerto Rico Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009, issued on August 31, 2016, as amended by the Resolution dated September 20, 2016.

Incident Summary

Name: 12JUL2022 Jayuya Outage Event – Jayuya 115/4.16 kV Substations #8301 and #8302 Outage, Loss of Load and Municipality
Date: July 12, 2022
Time: 05:50
Location: Jayuya 115/4.16 kV substations #8301 and #8302

Description: At 05:50 (5:50 a.m.) on July 12, 2022, an initial fault occurred at Jayuya 4.16 kV system affecting tied 115 kV/4.16 kV substations #8301 and #8302. This resulted in a fire, feeders 8302-4 and 8302-05 being destroyed, both Jayuya 1 substation #8301 and Jayuya 2 substation #8302 being de-energized, damaged equipment, the loss of two 115 kV lines (lines #39000 and #36400) and the loss of 6,208 customers. Restoration began at 06:50 (6:50 a.m.) with the arrival of LUMA crews and consisted of grounding, clean-up, isolation of feeders 8302-04 and 8302-5, repair and replacement of electrical wiring and equipment, electrical testing, and system reconfiguration. Necessary equipment has been repaired and returned to service. Feeders 8302-4 and 8302-5 were destroyed by the fire, and the clients from both feeders were tied to feeders 8301-01 and 8301-03, respectively, during restoration. Of the load being supplied by the original five distribution feeders, three were restored at approximately 17:00 (5:00 p.m.), and the remaining two loads were restored at approximately 17:30 (5:30 p.m.). All customers from the Jayuya substations were fully restored approximately 12 hours after the initial fault.

Resumen del Incidente

Nombre: Avería en Subestaciones #8301 y #8302 de 115 kV/4.16 kV en Jayuya, Pérdida de Carga y Municipalidad
Fecha: 12 de julio de 2022
Hora: 05:50
Localización: 115 kV/4.16 kV Subestaciones #8301 and #8302 en Jayuya

Descripción: A las 05:50 (5:50 a.m.) del 12 de julio de 2022, se produjo una falla inicial en el lado de 4.16 kV de las subestaciones de 115 kV/4.16 kV, # 8301 y # 8302 en Jayuya, las cuales se encontraban amarradas. Esto resultó en un incendio, destruyendo los alimentadores 8302-04 y 8302-05. Tanto la subestación Jayuya 1 # 8301 como la subestación Jayuya 2 # 8302 salieron de servicio debido a los equipos afectados, ocasionando la desconexión de dos líneas de 115 kV (líneas # 39000 y # 36400) lo que resultó en la pérdida de 6,208 clientes. La restauración comenzó a las 06:50 (6:50 a.m.) con la llegada de las primeras brigadas y consistió en la instalación de puestas a tierra, limpieza, aislamiento de los alimentadores 8302-04 y 8302-05, reparación y reemplazo de cableado y equipos eléctricos, pruebas eléctricas y reconfiguración del sistema. El equipo necesario fue reparado y puesto en servicio. Los alimentadores 8302-04 y 8302-05 fueron destruidos por el fuego y los clientes de ambos alimentadores fueron amarrados a los alimentadores 8301-01 y 8301-03 respectivamente durante la restauración. De la carga total suministrada por los cinco alimentadores de distribución originales, tres se restauraron aproximadamente a las 17:00 (5:00 p.m.) y las dos cargas restantes se restauraron aproximadamente a las 17:30 (5:30 p.m.). Todos los clientes de las subestaciones de Jayuya fueron completamente restaurados aproximadamente 12 horas después de la falta inicial.

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List of Acronyms

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- Feeder Circuit Breaker (FCB)
- Generator Circuit Breaker (GCB)
- Motor-Operated Disconnect (MOD)
- Oil Circuit Breaker (OCB)
- Potential Transformer (PT)
- Remote Terminal Unit (RTU)
- Transmission Center (TC)

1. Overview of Event

In compliance with Puerto Rico Energy Bureau's Resolution and Order issued July 13, 2022, in case number NEPR-IN-2022-0003, LUMA is providing the data collected and initial findings herein for the July 12, 2022, outage event at Jayuya Substation.

This report is based on the forensic analysis of the system and protection performance during the fault events at both 115 kV/4.16 kV Jayuya substations #8301 and #8302, the 115 kV transmission line #36400, including the remote terminal at Dos Bocas, and the 115 kV transmission line #39000 including the remote terminals at Toro Negro, Juana Diaz, and Barranquitas. The forensic analysis included the examination of outage event data, damaged equipment, repair updates, video recordings, and restoration timelines.

Since beginning operations on June 1, 2021, LUMA has been focused on repairing, restoring, and fundamentally transforming and modernizing Puerto Rico's energy system, which suffered from years - if not decades - of neglect under the prior operator. As has been well documented, nearly every aspect of the energy grid across Puerto Rico, including substations and other critical aspects of the T&D system, was weakened by past operational and maintenance failures, such as lack of maintenance and modernization.

With respect to the July 12th, 2022, Jayuya event, LUMA is committed to investigating the factors that may have led and contributed to this specific substation event, including 1) identifying and understanding the root cause of this event, 2) the role and impact of the fragile nature of the grid, and 3) the series of actions and improvements that must be taken by LUMA, to help prevent similar incidents from occurring again.

1.1 Event Details

This report is based on the outage event data, restoration timeline, and repair update of the disturbance event that caused a power outage on July 12th, 2022.

- Event name: OE2207-22 12JUL2022 Jayuya Outage Event
- Outage date: July 12th, 2022
- Outage time: 5:50 a.m.
- Number of clients impacted by the event: 6,208
- Location: Jayuya 115 kV/4.16 kV substations #8301 and #8302

The Jayuya substations were being supplied from the 115 kV line #36400 from Dos Bocas. Jayuya has two transformers that step-down voltage to supply the five 4.16 kV distribution circuits. These five 4.16 kV distribution circuits are called 8301-01 (F1), 8301-02 (F2), 8301-03 (F3), 8302-04 (F4), and 8302-05 (F5). Figure 1-1 is a one-line diagram of the Jayuya substations.

At 05:50:41.413, a fault occurred in the Jayuya substation #8302. The initial fault occurred on the downstream side of the feeder circuit breaker F5. The circuit breaker F5 failed to clear the fault and caused an electrical fire. This resulted in the melting of the high-side fuses of the transformers and an additional electrical fire at the 115 kV at or near the fuse holder. During the event and resulting electrical fires the 115 kV motor-operated disconnect MOD #36447 closed (*see* 1 below). The significant events are shown below:

1. At 05:51:02.540, 21.127 seconds after the fault at the 4.16 kV at Jayuya started, 115 kV MOD #36447 closed to expand the fault to line #39000. With MOD #36447 closed, line #36400 was transformed into a four-terminal line, with all its elements contributing short-circuit current to the fault at Jayuya. The four terminal 115 kV line included terminals Toro Negro (line #39000), Dos Bocas (line #36400), Barranquitas (line #39000), and Juana Diaz (line #39000).

2. At 05:51:26.79, OCB #39080 at Toro Negro tripped, 0.63 seconds after the fault at Jayuya 115 kV began and 45.377 seconds after the fault occurred on the 4.16 kV feeder F5.

3. At 05:51:26.91, GCB #36450 at Dos Bocas tripped, 0.75 seconds after the fault at Jayuya 115 kV began and 45.497 seconds after the fault occurred on the 4.16 kV feeder F5.

4. At 05:51:27.25, OCB #39042 at Barranquitas TC tripped, 1.09 seconds after the fault at Jayuya 115 kV began and 45.837 seconds after the fault occurred on the 4.16 kV feeder F5.

5. At 05:51:27.46, OCB #39062 at Juana Díaz TC tripped, 1.09 seconds after the fault at Jayuya 115 kV began and 46.047 seconds after the fault occurred on the 4.16 kV feeder F5.

1.2 Timeline of Events

The table below (Table 1-1) summarizes the timeline of the events of the outage, from the initiating event (fault on the 4.16 kV feeder F5) to the stabilization of the system after the fault was cleared by operations of the 115 kV lines.

Table 1-1 Timeline of Events

Time	Event
05:50:43.095	A three-phase fault is observed at the distribution level on line #36400 by the digital fault recorder at Dos Bocas.
05:50:43.635	Short-circuit current magnitude decreased at line #36400 as the F4 feeder's trip is shown in SCADA.
05:50:46.979	Short-circuit current magnitude at 115 kV phases A and B decreased for a short period and resumed afterward.
05:50:51.000	SCADA shows RTU failure signals.
05:51:02.540	MOD #36447 closed to expand the fault to line #39000.
05:51:26.160	A 115 kV side fault at Jayuya is sensed by the digital fault recorders.
05:51:26.790	The 115 kV OCB #39080 at Toro Negro hydroelectric plant opens to isolate the fault from that terminal.
05:51:26.910	115 kV GCB #36450 at Dos Bocas opens to isolate the fault from that terminal.
05:51:27.140	The 115 kV fault evolves to a phase-to-phase (A-C) fault.
05:51:27.250	The 115 kV OCB #39042 at Barranquitas TC trips.
05:51:27.461	115 kV OCB #39062 at Juana Díaz TC trips and clears the faults at Jayuya's substations from the system.
	System in stabile/normal state

1.3 System Status Prior to Event

The pre-disturbance/initiating conditions are presented in Figures 1-1 and 1-2:

- Substations #8301 and #8302 were tied at the 4.16 kV since May 2022.
- Instead of the recommended fuses, both substations had 65E standard speed fuses at 115 kV installed since PREPA. However, this did not contribute to the fire.
- 115 kV line #36400 from Dos Bocas was feeding both substations, via circuit breaker 36450.
- 115 kV MOD #36447 from Jayuya to line #39000 was open.
- Line #36400 to Ponce has been out of service since the 2017 hurricanes.
- A bypass with line #39000 was constructed to allow additional service to Jayuya via line #39000 at Toro Negro.
- Jayuya RTU indications show operational up/down were asserted before the event for unknown reasons.
- 4.16 kV voltages at substations #8301 and #8302 before the event were 4.43 kV in SCADA.

Figure 1-1 System Configuration Prior to the Event and Location of Faults

Figure 1-3 GIS Actual Locations at Jayuya

1.4 Transformers and Breakers Impacted During the Event

Table 1-2 below shows the equipment that operated or was impacted during this event.

Table 1-2 Other Major Equipment Affected

Equipment Type	Equipment Name	Date out (mm/dd/yyyy)	Time out	Date in (mm/dd/yyyy)	Time in	Duration (hr:min)
115 kV/4.16 kV	8301	07-12-2022	05:51:00			
115 kV/4.16 kV	8302	07-12-2022	05:51:00	07-12-2022	16:32:00	10:41
4.16 kV FCB	F1	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F2	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F3	07-12-2022	05:51:00	07-12-2022	16:43:00	10:52
4.16 kV FCB	F4	07-12-2022	05:50:00	07-12-2022	17:30:00	11:40
4.16 kV FCB	F5	07-12-2022	05:51:00	07-12-2022	17:30:00	11:40
115 kV GCB	36450	07-12-2022	05:51:00	07-12-2022	16:32:00	10:41
115 kV OCB	39080	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00
115 kV OCB	39062	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00
115 kV OCB	39042	07-12-2022	05:51:00	07-12-2022	05:51:00	00:00

1.5 Technical Details

This section provides the electrical characteristics and details.

1.5.1 Frequency Changes

Table 1-3 provides the system frequency before and after the event.

Table 1-3 Frequency Changes Before the Event

Prior to Event (Hz)	Immediately After 4.16 kV and 115 kV Event (Hz Minimum)
59.95	59.8

1.5.2 Voltage Changes

Table 1-4 provides the system voltage before and after the event.

Table 1-4 Voltage Changes at Dos Bocas 115 kV

Before (P-P kV maximum/minimum)	During (kV minimum)	After (kV maximum/minimum)
67.95/67.83	36.48	68.15/67.97

1.5.3 Equipment Malfunction or Damage

The following is a list of equipment that malfunctioned or was damaged during the event.

- 115 kV bus support damage was reported at substation #8301.
- 115 kV damaged insulator was reported at substation #8302.
- Jayuya RTU failure was reported.
- 115 kV MOD #36447 closed for unknown reasons during the fault event. There was an electrical fire, and the RTU dc failure alarm was seen at SCADA.
- 4.16 kV tie breaker at Jayuya substations was closed. This situation increased the short-circuit current beyond the short-circuit duty of the 4.16 kV feeder breakers F4 and F5.
- Short-circuit duty for breaker F4 was low for untied (tie breaker open) substations also. *See* short-circuit current in Appendix 1.
- Bird contamination was evident at the remaining 4.16 kV feeders.
- 115 kV phase B insulation was repaired.
- It was advised that although two fuses from substation #8301 and one fuse from substation #8302 were found melted, the remaining fuses had to be removed in pieces by field personnel.
- The AC supply to the battery charger was found damaged. It is not clear if this failure was a consequence of the fire at the substation.

1.5.4 Protection Performance

The following is a summary of the performance of the protection systems involved in the event.

- 4.16 kV breaker F5 overcurrent protection, 50/51, relays DPU-2000 (primary) and Microshield (secondary) could have operated, but the circuit breaker may not have been able to interrupt the fault current. Unfortunately, no fault record data was available to confirm the operation.
- 4.16 kV breaker F4 overcurrent protection, 50/51, relays IFC-77 could have operated, but the circuit breaker may not have been able to interrupt the fault current. Unfortunately, no fault targets were available to confirm the operation.
- Although 115 kV fuses at substation #8302 melted as intended (they are backup protection for the 4.16 kV fault), the 115 kV/4.16 kV transformers were tied at the 4.16 kV. If the tie circuit breaker had been open, this fault would have been cleared from the system by the fuses, as F4 and F5 are located in substation #8302.
- 115 kV fuses at substation #8301 failed to clear the fault at the distribution level, and the area experienced a fire creating a disturbance on the 115 kV side.
- Fault current available at the 4.16 kV with tied/paralleled substations #8301 and #8302 exceeded short-circuit duty of F4 and F5 of 16kA and 20kA, respectively.
- Fault current available at the 4.16 kV from transformer #8302 for (untied/paralleled) substations exceeded short-circuit duty of F4. This 115 kV/4.16 kV transformer was replaced by a larger one in 2016.

Table 1-1 provides an overview of the category and causes of malfunction of the protections systems involved in the event.

Table 1-1 Protection Maloperation

Category		Cause(s) of Maloperation	
Yes	Failure to trip during a fault	Yes	AC system
No	Failure to trip other than fault	No	As left personal error
No	Slow trip during fault	No	Communication failures
No	Slow trip other than fault	Yes	DC system
No	Unnecessary trip during a fault	No	Incorrect setting/logic/design error(s)
No	Unnecessary trip other than fault	No	Relay failures/malfunctions
No	Unnecessary outage	No	Unknown/unexplainable

2. Investigation and Analysis

With respect to the July 12th, 2022, Jayuya event, LUMA is committed to investigating the factors that may have led and contributed to this specific substation event, including 1) identifying and understanding the root cause of this event, 2) the role and impact play by the fragile nature of the grid, and 3) the series of actions and improvements that must be taken by LUMA, to help prevent similar incidents occurring again.

The following section includes the details of the investigation and the analysis of the evidence.

2.1 Summary of Details of the Event

The following is a chronological summary of the events. The transient recorder installed at Ponce and SCADA were used as time references.

- Emergency tie circuit breaker at the 4.16 kV was closed before the fault. The 115 kV/4.16 kV transformers from substations #8301 and #8302 at Jayuya were tied and in parallel operation.
- An unknown fault affected feeders F4 (#8302-4) and F5 (#8302-5) and was not cleared instantly by their protection as intended. No faults or deficiencies were reported outside the substation. Wildlife contamination was observed after the fault incident at the remaining feeders F1, F2, and F3.
- Short-circuit current present with the 115 kV/4.16 kV transformers tied in parallel on the 4.16 kV and this exceeded the short-circuit duty for the breakers F4 and F5 consisting of 16kA and 20kA, respectively.
- Transformer #8302 was installed in 2016, and it is a larger unit, which means that the available short-circuit currents exceeded the circuit breaker rating of 16 kA for breaker F4, even with the tie switch open.
- Feeder breaker F4 is shown in SCADA as OPEN almost a second after the fault initiated. SCADA shows breaker F4 closed ten seconds later. It is not clear if breaker F4 initiated the fault and affected breaker F5. It is not clear if breaker F4 later reclosed or if this was an RTU signal malfunction because this was not a programmed reclose sequence timing. There was a fire in the substation at this time.
- Digital fault recorders from Dos Bocas, Ponce, and Aguas Buenas demonstrated that 115 kV MOD #36447 closed 21.127 seconds after the fault at the 4.16 kV was initiated. This action tied 115 kV line #39000 with line #36400. There was a fire in the substation and the battery charger MOD dc alarms were present when the MOD closed.
- With MOD #36447 closed, a four-terminal 115 kV line was formed between Dos Bocas, Barranquitas TC, Juana Díaz TC, and Toro Negro H.P.
- The 115 kV fuses at substation #8301 did not melt and rather burned for a considerable period. In the video, the fuse area is shown on fire before the fault at the 115 kV bus support is seen as an arc flash.
- Substations #8301 and #8302 installed fuses during the event were S&C type SMD-2B 65E standard speed. The recommended fuses are S&C type SMD-2B 50E standard speed and S&C type SMD-2B 65E slow speed, respectively. *See* Figure 1-1 and Appendix #1. This was not the cause for the 4.16 kV at F4 and F5 fault-clearance delay. However, the reason these fuses were used or the condition of the fuses could not be determined.
- A 115 kV phase-to-ground fault was evident in the video and at the transient recorders. Toro Negro OCB #39080 and Dos Bocas GCB #36450 in reaction to the B-G fault.
- The 115 kV fault at substation #8301 evolved to a phase-to-phase fault. OCB #39042 at Barranquitas and OCB #39062 at Juana Díaz tripped to clear both 4.16 kV and 115 kV faults at Jayuya from the system.

2.2 Sequence of Events Investigation

Before the fault, Jayuya substations were served via 115 kV line #36400 from Dos Bocas. MOD #36447 to line #39000 and line #36400 to Ponce was open. Figure 1-2. Digital fault recorder (DFR) at Dos Bocas showed load currents at the line were I_a = 29.35A, I_b = 30.11A, and I_c= 25.51A.

2.2.1 Jayuya 4.16 kV Fault Initiation at 05:50:41.413

At 05:50:41.413, a phase-to-ground fault at the 4.16 kV is sensed by the DFR. Due to the delta-wye transformer between the 4.16 kV and the 115 kV system, the phase-to-ground fault on the 4.16 kV causes equal but opposite polarity fault currents, of much less magnitude, in two phases on the 115 kV side. *See* Figure 2-1. After 0.05 seconds, the fault evolved to a three-phase fault. The 115 kV line #36400 at Dos Bocas DFR short-circuit currents were I_a = 855A, I_b = 825A, and I_c= 870A.

Figure 2-1 Dos Bocas Digital Fault Record – Initial Segment 05:50:43

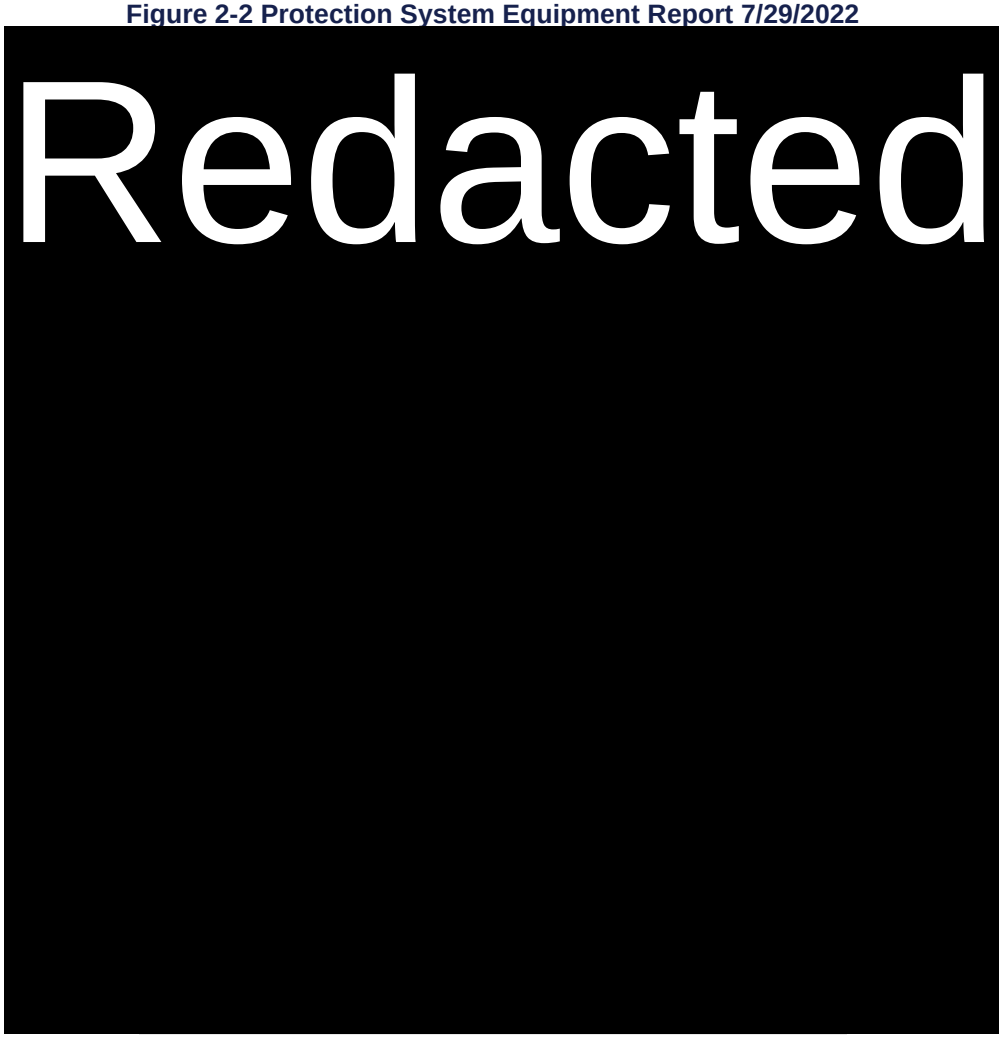
With both 115 kV/4.16 kV transformers tied, at the 4.16 kV the actual short-circuit current for the fault at feeder breakers F4 and F5 was 22,806.5 amperes (A), *see* Table 2-1. This short-circuits current registered by the DFR exceeded both feeder breaker ratings of 16kA and 20kA, respectively. It is suspected that the fault originated at the substation on 4.16 kV. No deficiencies on those feeder breakers F4 and F5 were found or on the feeder outside the substation.

2.2.2 Protection at Dos Bocas

The protection at Dos Bocas correctly did not respond to the initial 4.16 kV fault. A fault in the distribution system typically should not be cleared by transmission protection.

The protection ground element was not challenged by the fault that did not produce any zero-sequence current. The delta-wye transformer isolated the zero-sequence component between the 4.16 kV and 115 kV systems. Only later, when the fault became a ground fault on the 115 kV system, did the Dos Bocas protection operate as designed.

Figure 2-2 Protection System Equipment Report 7/29/2022



The distance element, provided by CEB-52 and CEY-52, are set with pick-up values that did not enable them to detect a fault on the low side of the 115 kV/4.16 kV transformer. The relay correctly did not operate for the initial 4.16 kV fault.

2.2.3 Substation #8302 115 kV Fuses Acted (Melted)

From the short-circuit analysis using the Dos Bocas DFR record, per unit short circuit and current divider analysis, the actual short-circuit currents from the 115 kV/4.16 kV transformers to the fault at the 4.16 kV feeders #8302-4 and #8302-5 were compared to the Computer-Aided Protection Engineering (CAPE)

analysis performed by Protection, Automation and Control (PAC), *see* Appendix 1. For the study, the actual fuses (65E standard) were analyzed. The short-circuit currents were similar as follows:

Table 2-1 DFR (Real Time) vs. CAPE (Simulation) Short-circuit Evaluation - Tied Substations

Location	I_{sc} CAPE (A)	Total Clearing Time (S)	I_{sc} Dos Bocas DFR (A)	Total Clearing Time (S)
Redacted				

Table 2-1 shows the average 825A registered by the Dos Bocas DFR at the fault initiation divided between the substations as follows:

- Substation #8301 – Highest per unit impedance 115 kV/4.16 kV transformer. The short-circuit current at the fault initiation on the 115 kV side was 338.4A. The total clearing time for the installed 65E standard speed fuses was expected to be 1.17 seconds with this short-circuit current present. That did not happen.
- Substation #8302 – Lowest per unit impedance 115 kV/4.16 kV transformer. The short-circuit current at the fault initiation on the 115 kV side was 486.6A. The total clearing time for the installed 65E standard speed fuses was expected to be 0.54 seconds with this short-circuit current present. The observed fuse clearing time was 0.56 s.
- The short-circuit current at the 4.16 kV during the fault was 22,806A. This current exceeded the short-circuit duty for both feeder breakers F4 and F5.

Near this time, 4.16 kV circuit breaker F4 is shown in the OPEN position in SCADA as follows:

07/12/22 0550:42 JAYUYA 4 8302-4 BKR STATUS OPEN

2.2.4 Short-circuit Current via Substation #8301 115 kV/4.16 kV Transformer at 05:50:43.635

At 05:50:43.635, the sustained three-phase, short-circuit current of 825A+ seen at line #36400 decreased to I_a = 431.7A, I_b = 432.3A, and I_c= 413.9A. *See* Table 2-1. It is assumed that substation #8302 fuses cleared the short-circuit current contribution from that substation to the fault at the 4.16 kV.

Table 2-2 Short-circuit Evaluation 115 kV/4.16 kV Substation #8301

Location	I_{sc} CAPE (A)	Total Clearing Time (S)	I_{sc} Dos Bocas DFR (A)	Total Clearing Time (S)
Redacted				

Table 2-2 shows that with the three-phase, short-circuit current present, the installed 65E standard speed fuses installed at the #8301 transformer should have cleared the fault in 0.72 seconds at the most if the initial short-circuit current is accounted for.

2.2.5 Short-circuit Current Decreased at 05:50:46.979

At 05:50:46.979, DFR in Figure 2-3 shows that the sustained fault currents at phases A and B decreased for a few milliseconds and resumed. I_a = 4.8A, I_b = 121.4A, and I_c = 118.54A. It could be possible that a fuse melted at substation #8301 at that point, but the current path was not cleared for some reason.

It could be observed that after 0.5 seconds, the distortion ceases, and the short-circuit currents are present in the 115 kV, mostly on phase B as I_a = 229.9A, I_b = 428.5A, and I_c = 200.8A.

Figure 2-3 Dos Bocas DFR 05:50:46.979

2.2.6 SCADA RTU Signals at 05:50:50.000

At 05:50:50.000, SCADA shows failing signals at the substation:

Figure 2-4 SCADA RTU Signals

Redacted

2.2.7 MOD #36447 to 115 kV Line #39000 Closed Unexpectedly at 05:51:02.540

At 05:51:02.540, 21.127 seconds after the fault at the 4.16 kV at Jayuya started, 115 kV MOD #36447 closed to expand the fault to line #39000. SCADA and the DFRs from Ponce TC, Aguas Buenas' gas-insulated substation, and Dos Bocas recorded this situation. With MOD #36447 closed, line #36400 was transformed in a four-terminal line, with all its elements contributing short-circuit current to the fault at Jayuya.

SCADA RTU signals show multiple alarms like device failure, battery charger alarm, ground fault, ac to the battery charger alarm, and the MOD at Jayuya substation lost the dc:

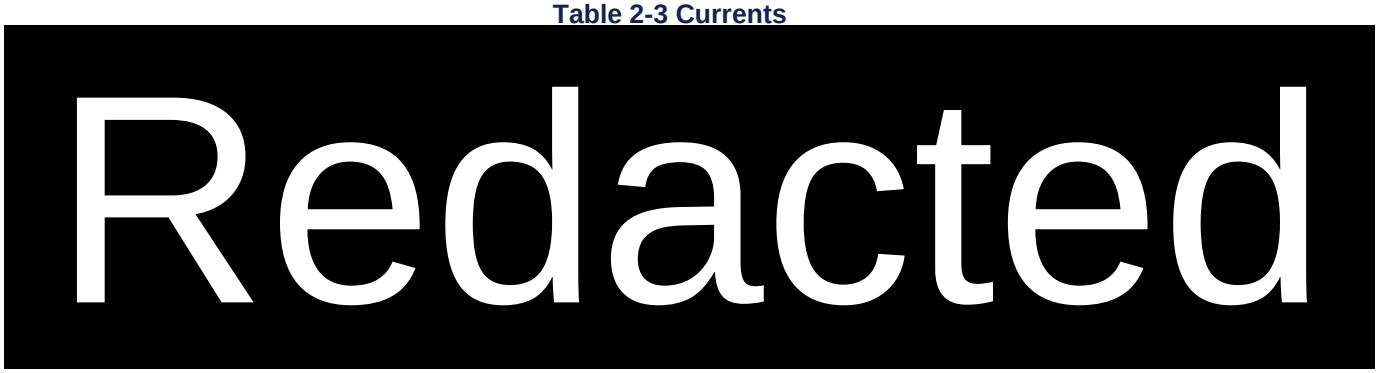
Figure 2-5 SCADA RTU Signals

Redacted

Figure 2-6 MOD #36447 Closed. I_{sc} from Dos Bocas Decreased.

As the MOD #36450 closes, the currents at Ponce and Aguas Buenas DFRs increase, and the current at the Dos Bocas DFR increase, see table below:

Table 2-3 Currents



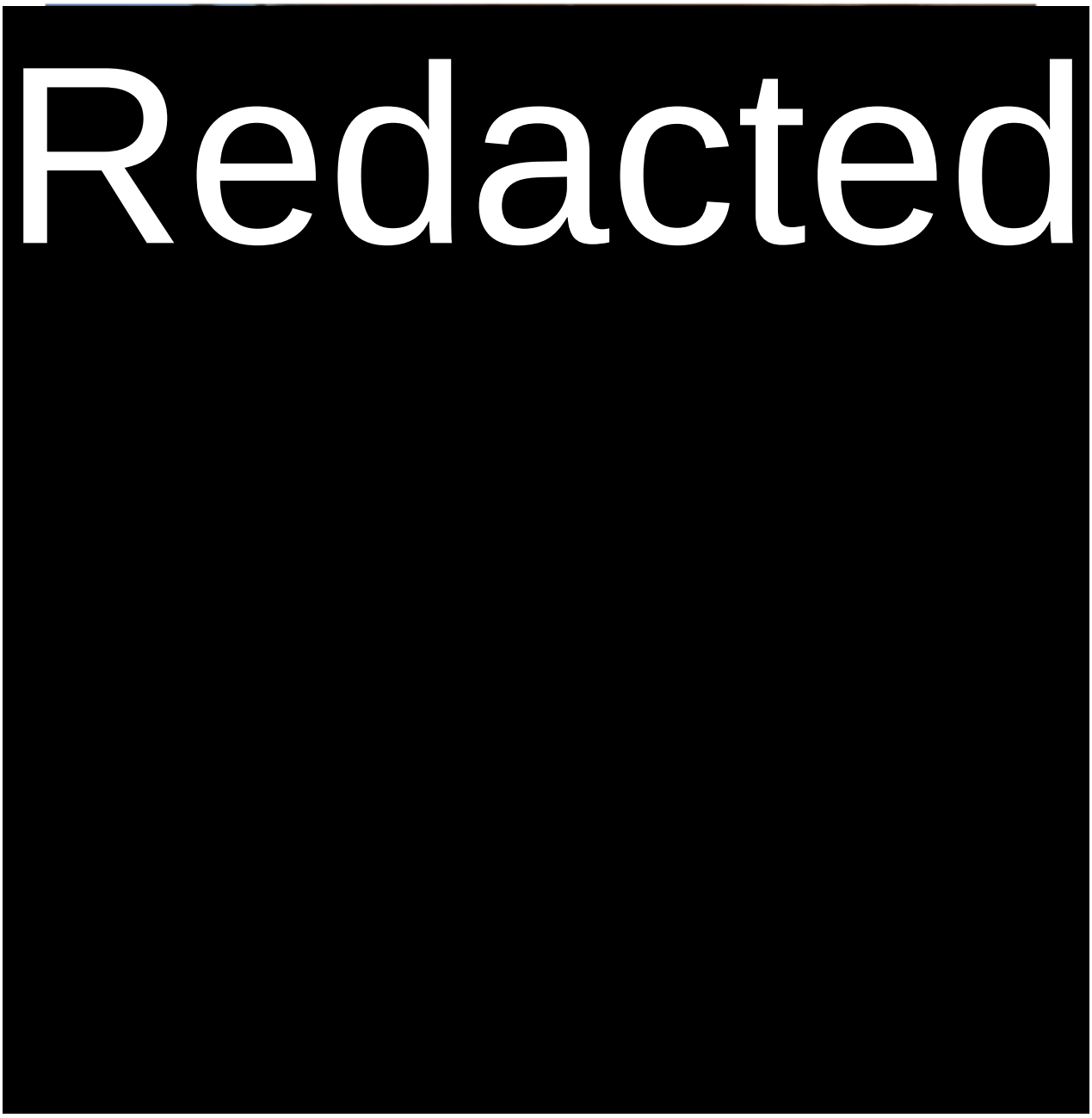
2.2.8 Burning 115 kV Fuse Area at Substation #8301 – Fuses did not Clear the Fault

A video containing the last 21 seconds of the fault at Jayuya was analyzed. The sequence of events from this video shows that the 115 kV fuse area at substation #8301 was burning, and the fuses did not clear the fault at the 4.16 kV for at least 19 seconds.

Figure 2-7 Fire at Jayuya F4, F5 and Substation #8301; 15th Second

In Figure 2-7 and Figure 2-8, it is evident that the 115 kV fuses from 115 kV/4.16 kV transformer #8302 were already out of service. This is consistent with the assumption that the fuses from 115 kV/4.16 kV transformer #8302 melted, and this transformer was not contributing to the fault at the 4.16 kV at this time. *See* findings from the transient record currents at the event initiation in Section 2.2.1.
The DFR at Dos Bocas 115 kV line #36400 sensed the 4.16 kV fault as follows: I_a = 221.54A, 218.15A, 227.15A.

Figure 2-8 Fire at F4, F5 and 115 kV Substation #8301 Fuse Area; 18th Second



2.2.9 115 kV Bus Support Fault at Jayuya Substation #8301 at 05:51:26:160

At the 19th second of the fire video at Jayuya substation, an arc fault is visible at the already burning fuse area from substation #8301, *see* Figure 2-9.

At 05:51:26:160, the DFRs sensed a phase B-to-ground fault at the 115 kV. Short-circuit currents at Dos Bocas were I_a = 153.4A, I_b = 1170A, and I_c = 227.1A. A damaged phase B bus support was found at #8301.

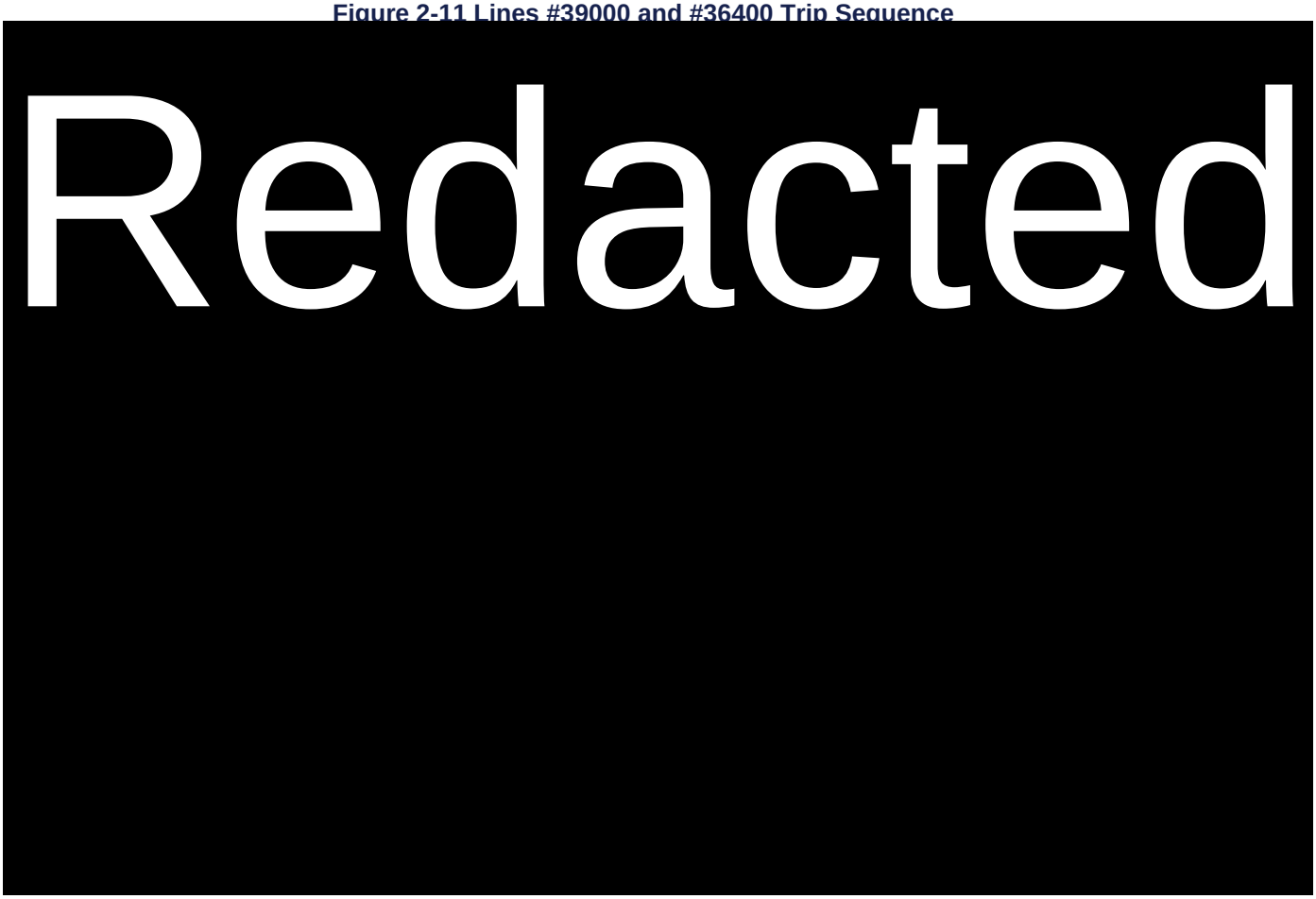
Figure 2-9 Fault at Substation #8301 115 kV

Figure 2-10 Dos Bocas DFR Fault at Jayuya #8301 115 kV

2.2.10 Toro Negro 115 kV OCB #39080 Tripped at 05:51:26.79

At 05:51:26.79, OCB #39080 at Toro Negro tripped, 0.63 seconds after the fault at Jayuya 115 kV began and 45.377 seconds after the event in the 4.16 kV initiated. *See* Figure 2-11.

Figure 2-11 Lines #39000 and #36400 Trip Sequence



2.2.11 Dos Bocas 115 kV GCB #36450 Open at 05:51:26.91

At 05:51:26.91, GCB #36450 at Dos Bocas tripped, 0.75 seconds after the fault at Jayuya 115 kV began and 45.497 seconds after the event in the 4.16 kV initiated. *See* Figure 2-10.The inverse time overcurrent ground protection, relay JBGG-51, tripped correctly for a 3I0 =379A contribution to the Jayuya 115 kV fault from Dos Bocas.

2.2.12 115 kV Fault at Jayuya Evolved to Phase-to-Phase Fault at 05:51:27.140

At 05:51:27.140, during the 20th second of the fire video at the Jayuya substation, the arc fault at the #8301 115 kV evolved to a phase-to-phase fault. *See* Figure 2-11 and Figure 2-12.

Figure 2-12 Phase-to-Phase Fault at #8301 115 kV

2.2.13 Barranquitas 115 kV OCB #39042 Tripped at 05:51:27.250

At 05:51:27.250, OCB #39042 at Barranquitas TC tripped, 1.09 seconds after the fault at Jayuya 115 kV began and 45.837 seconds after the event in the 4.16 kV initiated. *See* Figure 2-11.

2.2.14 Juana Díaz 115 kV OCB #39062 Tripped at 05:51:27.460

At 05:51:27.460, OCB #39062 at Juana Díaz TC tripped, 1.09 seconds after the fault at Jayuya 115 kV began and 46.047 seconds after the event in the 4.16 kV F4 and F5 initiated. *See* Figure 2-12.

With this 115 kV OCB #39062 open, the faults at Jayuya were cleared from the system. Figure 2-12 shows OCB #39062 automatically reclosed successfully after 10 seconds without a fault present in the system.

Only load current is present at 115 kV line #39000 from Ponce to Juana Díaz TC. The 21st second of the video, shows the fault was cleared from the system.

Figure 2-13 Juana Díaz OCB #39062 Tripped to Clear the Fault and Reclosed

3. Root Causes and Recommendations

LUMA is committed to investigating all the factors that may have led and contributed to the July 12th event and is determined to identify and understand the root cause and actions that must be taken to mitigate against similar incidents occurring again. Some equipment was destroyed in the fires that could have provided definitive causal analysis. The root cause analysis incorporated all data available, including examination of outage event data, damaged equipment, repair updates, video recordings, and restoration timelines.

3.1 Root Causes

The two Jayuya substations were connected and paralleled via a bus breaker, on the 4.16 kV bus. The 4.16 kV feeder breakers F4 and F5 were not rated to clear the collective fault current from both transformers, and when the fault occurred, breaker F5 failed to clear the fault and started an electrical fire. Please refer to section 1.5.4, Protection Performance, for additional details concerning the operation of the protection systems.

Additional discussion:

- Although the 115 kV fuses at substation #8302 melted (they are backup protection for the 4.16 kV fault), the 115 kV/4.16 kV transformers were tied at the 4.16 kV, and the fuses on #8301 also needed to melt to clear the faults on the 4.16 kV.
- The 115 kV fuses at substation #8301 failed to clear the fault on the 4.16 kV, and the 115 kV area of the fuses experienced a fire creating a disturbance on the 115 kV side. However, if the tie circuit breaker had been open, this fault would have been cleared from the system by the fuses on #8302, as F4 and F5 are located in substation #8302.
- The unintended closing of the 115 kV MOD #36447 that created a 4 terminal 115 kV system occurred after the fire on the 4.16 kV and 23 seconds after the initiation of the event.
- After the fire, no AC supply to the battery charger (DC circuit) was found. It is not clear if this condition existed before or was a consequence of the fire at the substation. Moreover, the DC alarms at MOD# 36447 were present only when the closing failure occurred.

3.2 Recommendations

LUMA is determined to address the conditions that led to this event and continues to improve reliability by making the following recommendations:

- Return Jayuya to normal and reliable operating conditions, including repair and replacement of damaged equipment.
- Share the lessons learned with System Operations and Protection, build awareness, and prevent this situation in the future.
- Examine the system for similar situations and correct them.
- Use the events of the Jayuya outage to build a more reliable and resilient system, such as the replacement of fuses with active devices.

Appendix 1: PAC Short-circuit Simulation Using CAPE

The PAC personnel performed short-circuit simulations using the CAPE program. The investigation analyzed these times and compared them to real-time digital fault recorder data to verify the protection performance during the event. It was found that:

- The installed fuses in the substations were not the ones recommended by PAC, but this situation did not explain why the #8301 fuses did not react. The installed fuses at this substation were faster.
- However, the reason these fuses were used, or the condition of the fuses could not be determined.
- The installed fuses could be considered alternate options if the recommended fuses were not available.

Various scenarios were required for the simulations that include the results for the 115 kV fuses' minimum melting and total clearing times. The scenarios are as follows:

1. Only 115 kV OCB #36450 from Dos Bocas serving **TIED** substations #8301 and #8302.
2. Only 115 kV OCB #36450 from Dos Bocas serving **UNTIED** substations #8301 and #8302.
3. CBs #36450, #39062, #39080 and #39042 serving **TIED** #8301 and #8302. MOD #36447 OPEN.
4. CBs #36450, #39062, #39080 and #39042 serving **UNTIED** #8301 and #8302. MOD #36447 CLOSED.

Table Appendix 1-1 115 kV Minimum Melting Times

Redacted

Table Appendix 1-2 Jayuya 115 kV Fuses Total Clearing Times

Redacted